CFD Problems Numerical Simulation and Visualization by means of Parallel Computation Systems

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ABSTRACT

Nowadays numerical simulation of complicated CFD problems by means of parallel computation is widely used all over the world. There are many CFD codes which can work on multiprocessor systems. The GasDynamicsTool® (GDT) package developed by GDT Software Group is one of them. It is meant for the numerical simulation of gas-dynamic processes in a wide range of initial and boundary conditions. Fluid jets, inner and outer problems of aerodynamics, ballistics, combustion and detonation, fluid-structure interaction – these are just a few of the phenomena that can be simulated with the help of the GDT package.

GDT can work on different software and hardware platforms, including parallel computation systems. The package is based on modified large particle method and uses uniform cubic grid. Parallelization is provided by means of computation domain division into a number of subdomains. The number of subdomains equals the number of cluster nodes. On every time step each node calculates the results in every grid cell of its subdomain, and after that the subdomain boundary cells results exchange between the nodes takes place.

As a result of such approach GDT has an outstanding computation speed and good scalability characteristics. For example, one time step computation for the 960 million 3D cells domain on 16-node cluster of ICAD RAS lasts 39 seconds. The package is capable of computing up to 30 million 3D cells for each gigabyte of the working memory.

GDT Software Group achievements in solving CFD problems are listed below.

1. Rocket systems functioning.
"Proton" carrier rocket launch from the launching pad, booster separation processes, rocket cowl opening process (fig. 1), flow around landing module, etc. were simulated using the GDT package.
2. Combustion and detonation.
High explosive charges detonation, explosions inside and near buildings, explosion in a destruction chamber (fig. 2), fuel-air explosions were simulated by GDT Software Group. The results obtained can be used in counter-terrorist activities.
3. Ecology problems.
GDT allows simulating air pollution propagation processes. Two problems were solved: simulation of air pollution caused by accident on chemicals plant and simulation of air pollution caused by city traffic (fig. 3).
5. Artillery systems functioning.
A number of problems such as: gun brake functioning, twin barrel system operation, quick-firer operating, gas flow around the shell, etc. were simulated. Pressure and temperature effect on construction elements was estimated.

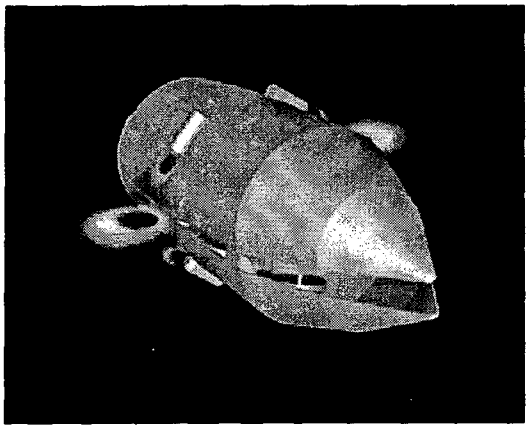

Fig. 1 – Cowl opening. Pressure distribution

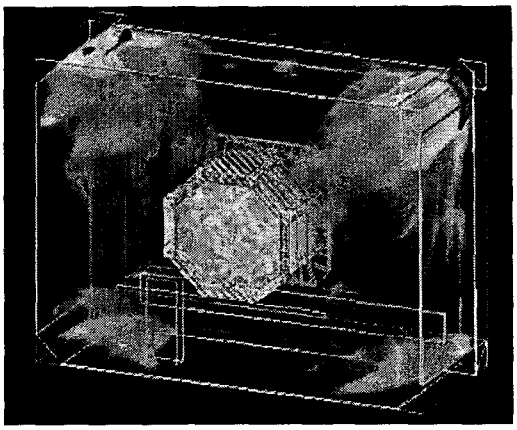

Fig. 2 – Explosion in destruction chamber. Pressure distribution

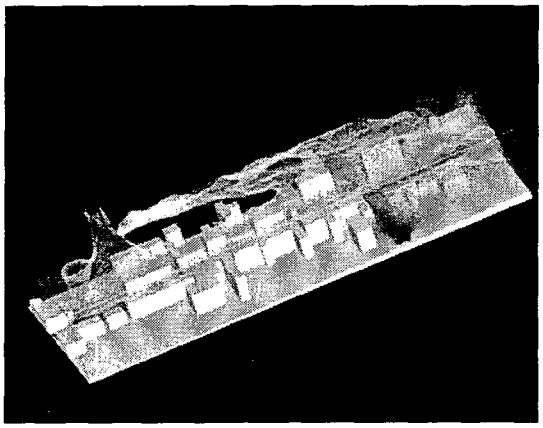

Fig. 3 – Air pollution by traffic in the city. Products concentration.

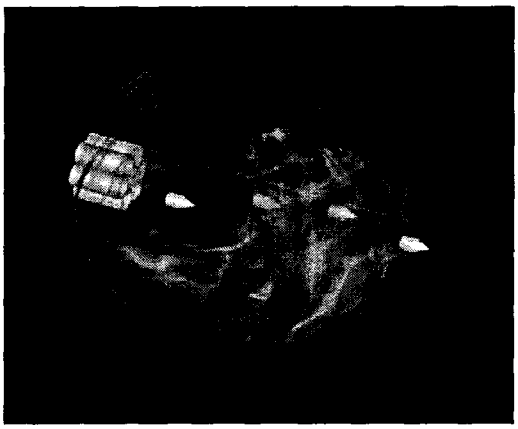

Fig. 4 – Quick-firer operation. Pressure gradient modulus distribution

Data obtained from computation cluster was visualized by means of ScientificVR® (SVR) visualizer developed by GDT Software Group.
As part of the hybrid version of the GasDynamicsTool package, it is featuring "on-the-fly" dynamic visualization of data obtained from nodes of distributed computing systems. Here a modified variant of visualization on a visualization node is used (fig. 5).

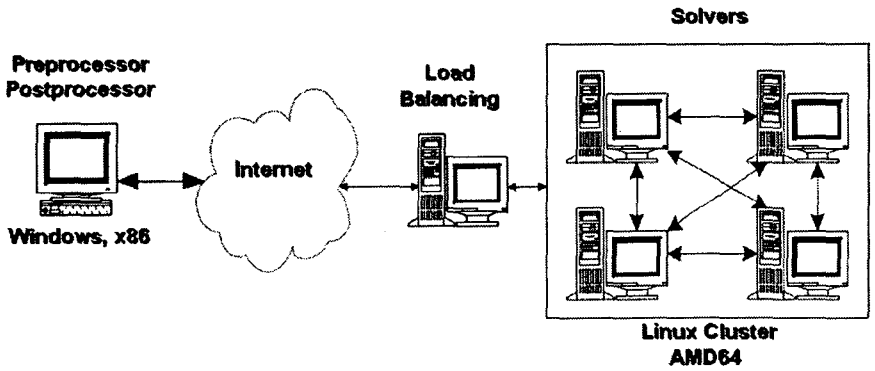

Figure 5 – Functioning pattern of the hybrid technology

The most significant features of the visualizer are the following: on-the-fly extra large data visualization, plug-in architecture, semitransparent voxel graphic and full color 3-d stereoscopic presentations.